

EFFECTS OF DINOSEB AND ETHEPHON ON THE YIELD
OF CORN (ZEА MAYS, L.) AND GRAIN SORGHUM
(SORGHUM BICOLOR, (L.) MOENCH).

by

SAMUEL TEMITAYO JAIYESIMI

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Major Professor.

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INTRODUCTION.

Corn (Zea mays, L.) and grain sorghum (Sorghum bicolor, (L.) Moench) are two crops of immense importance to the economy of the Great Plains. Consequently any practice that will increase yields of these crops is always welcome. Dinoseb (2-sec butyl-4,6-dinitrophenol) traditionally used as a herbicide recently has been proclaimed as a yield stimulant when applied to corn foliage at low rates and at the proper stage of development. Ethephon (2-chloroethane-phosphonic acid) is another growth promoting chemical that is currently being tested on grain crops.

Results have been conflicting on the mode of action of dinoseb on yield response at the very low rates suggested. Earlier silking date and decreased barrenness are major reasons that have been advanced for the increase in corn yield (4). Other workers have not been able to consistently obtain yield increases on corn. Results on ethephon have also varied with different crops (2,6,8,14).

These two chemicals were applied to corn and grain sorghum to investigate their effects on yield, and in the case of grain sorghum to determine the best time of application.

REVIEW OF LITERATURE.

Dinoseb (an alkanolamine salt of 2-sec butyl-4,6-dinitrophenol) is described as a direct contact herbicide with essentially no true translocation and the mechanism of action being direct cell necrosis (17). Interest in the material as a yield stimulant arose from the work of Dr. A.J. Ohlrogge and associates (4) at Purdue University. They found low rates of dinoseb, 12.4 gm/ha (5gm/ac.) gave significant yield increases.

Other workers have tried dinoseb on corn and sorghum. The results of these trials have not been consistent. In reviewing the work done with dinoseb as a yield stimulant, Regan (11) suggested that earlier silking, reduced number of barren plants, and reduced severity of fungus diseases might be reasons for yield increases. These same suggestion were first advanced by Hatley, et al (4). Regan (11) also reported results of 1975 tests of dinoseb on grain sorghum in California where yield increases of 2 to 4% were achieved with the application of 12.4gm and 24.8gm per hectare (5.0 and 10.0gm/ac. respectively).

Barnes, et al. (1) found no significant yield increase when dinoseb was applied to corn in Iowa in 1975. Their results were in agreement with two trials at the University of Minnesota in 1974 and two in 1975 trials at the University of Illinois (1).

Kapusta and Strieker (5) reported a 4 bushel yield increase with 3gm/acre dinoseb applied to grain sorghum in 1975 which was not significant. The same rate (also applied as Premerge)

1976 decreased yields.

Ethephon, a plant growth regulating chemical, acts by releasing ethylene into plant tissues which produces numerous physiological effects and can be utilized to regulate various phases of plant metabolism, growth, and development (3). It has been shown to affect leaf abscission (10), and fruit ripening processes (7,13).

Within the last few years several workers have evaluated the response of cereals to applications of ethephon (Ethrel^R). Marais and Graven (8) applied 0.7 kg Ethrel/ha on corn 7 weeks after plant emergence. They reported between 3 and 9 percent yield increase and concluded that Ethrel eliminated lodging, and increased net assimilation rate and crop growth rate. This increased yield response was not found on beans (Phaseolus vulgaris), spring wheat (Triticum aestivum), or grain sorghum (2,5,9,14). Turker, Milton, and Webster (14) reported a slight yield increase of beans with application of 56gm a.i. ethephon/ha at the white bud stage and a yield decrease at higher rates and when applied at full bloom although neither increase nor decrease was significant. Bolger and Gallagher (2) found a reduction in spring wheat yield due to spraying with Ethrel, and straw length decreased more when Ethrel was applied at growth stage 8 (Feeke's scale) than when applied at growth stage 5. Kapusta and Strieker (5) and Norwood (9) found no yield differences on grain sorghum due to ethephon. Kuizenga (6) reported Ethrel increased winter rye yield 19 percent.

METHODS AND MATERIALS

Field plots.

Research to find possible explanation into the probable effects of dinoseb (as Spark) as a growth stimulant on corn was conducted at the Agronomy Farm, Manhattan, Kansas, in 1976. Dinoseb and ethephon (as Ethrel) were tested at different rates and growth stages on grain sorghum also at Manhattan while only dinoseb was tested on grain sorghum at the Garden City Branch Experiment Station in 1976.

Corn Experiment.

Two corn hybrids, Dekalb XL64 and Pioneer 3369A, were planted on May 13, 1976. Treatments were three rates of dinoseb, 0, 6.2, and 12.4 gm. a.i. per hectare, Benlate at 1.68 kg/ha, liquid nitrogen at 1.12 kg/ha, and surfactant (as Spret) at 2.5% of the highest dinoseb rate. All the materials were sprayed on the crop on July 6, 1976 with a high clearance tractor mounted sprayer. The tassels of Dekalb XL64 were about 4 inches long while those of Pioneer 3369A were between 2½ and 3 inches long at the time of spraying.

The experimental design was a modified split-plot with hybrids as main plots (strips), treatments as sub-plots, and six replications. Sub-plots were four 76.2 cm rows, 7.62 meters long with 4.57 m of the two middle rows harvested on September 18, 1976.

Pre-plant application of 56 kg N/ha was made across the entire field on May 10. Bladex (2.24 kg/ha) and Lasso (2qts)

were applied on May 11 for weed control. Plots were machine planted at a population of 50,180 plants per hectare.

Data were collected on days to 50% silking, barrenness, ear weight, ear number, percent two-eared plants, and weight of 1000 kernels. Yield data were determined on an individual sub-plot basis and then converted to a hectare basis corrected to 15.5% moisture.

Sorghum Experiments.

Grain sorghum (RS 671) was planted on May 26, 1976 at Manhattan. Five rates of dinoseb, 0, 6.2, 12.4, 18.6, and 24.8 gm/ha, two rates of ethephon (0.28 and 0.56 kg/ha), and a surfactant (Spret, 2.5% of the highest dinoseb rate) were applied with a high clearance tractor mounted sprayer at four stages of growth as identified by Vanderlip (15), and Vanderlip and Reeves (16). Dates of treatment application and corresponding growth stages are summarized in Table 1.

Table 1. Dates of treatment application on grain sorghum at Manhattan, Kansas, in 1976.

<u>Date applied</u>	<u>Growth Stage</u>
7-2-76	Growing Point Differentiation (GPD).
7-16-76	Flag Leaf Visible (Flag).
7-26-76	Boot.
8-6-76	$\frac{1}{2}$ Bloom.

The experimental design was a split-plot with stages

at which treatments were applied as main plots and treatments as sub-plots with five replications. Sub-plots were four 76.2 cm rows, 7.62 m long with 4.57 m of the two middle rows harvested on September 23 and 24, 1976.

Nitrogen (71.7 kg/ha) and phosphorus (134 kg/ha) were applied on May 5. On May 10, 3.36 kg Milogard per hectare was applied for weed control. Cygon (0.87 liters/ha) was sprayed on the crop on June 4 to control green-bugs.

Data collected included days to 50% flowering, number of heads per plot, grain weight per plot, number of kernels per head, and weight of 1000 kernels. Yield data were converted to a hectare basis, corrected to 15.5% moisture.

Both the corn and sorghum experiments at Manhattan were on a Reading silt loam soil.

The Garden City experiment on grain sorghum (TE-Y-101R) was planted May 19, 1976. Three rates of dinoseb, (0, 6.2, and 12.4 gm/ha) were tried along with the surfactant (also at 2.5% of the highest dinoseb rate). The treatments were applied on July 31 which corresponded to the boot stage of growth.

The experimental design was a randomized block with four replications. Plot size was four 76.2 cm rows, 7.62 m long. The two middle rows were harvested on October 22. Soil type was Keith silt loam. The entire field was irrigated four times during the growing season.

Anhydrous ammonia (168 kg/ha) and 2.24 kg Igran tank-mixed with 1.12 kg Milogard per hectare, for weed control, were applied pre-plant. Metasystox was sprayed to control greenbugs.

Statistical Procedure.

Analyses of variance were performed on days to 50% silking, number of ears per plant, ear weight, percent barren plants, percent 2-eared plants, and grain yield per hectare on corn and on days to 50% flowering, number of heads per plot, grain weight per head, weight of 1000 kernels, number of kernels per head, and grain yield per hectare on sorghum according to Snedecor and Cochran (10). The analyses are summarized in tables in the appendix, which identify significant (5% level) and highly significant (1% level) F values.

Growth stages at which applications were made and all interactions were evaluated. Differences due to hybrids in the corn experiment were not evaluated since the hybrids were not randomized in each replicate.

RESULTS AND DISCUSSION.

Corn Experiment.

Results from the corn experiment at Manhattan showed no treatment differences nor any interaction between hybrids and treatments for any of the characters studied (Appendix Tables 10 and 11). Only hybrid differences were significant and these were not evaluated per se.

Silking was not hastened by application of dinoseb (Table 2) which does not agree with Hatley, et al. (4) who concluded that two extra days for filling the kernels due to earlier silking must have been responsible for the yield increase they found.

Pioneer3369A produced slightly heavier ears than Dekalb XL64 but there were no treatment effects on either hybrid (Table 2). Number of ears per plant (Table 2) and kernel weight (Table 3) were neither affected by the treatments nor was there any hybrid by treatment interaction.

As compared to the control, there was a trend toward reduction in percent barren plants in the treated plots and a slight increase in the percentage of two-eared plants (Table 3). However these differences were not significant and were not great enough to increase yield. Dekalb XL64 produced significantly more two-eared plants than Pioneer 3369A. The trend toward reduction in number of barren plants by the dinoseb treatments may be due to the surfactant (Table 3) though the mode of action is not known. Benlate and nitrogen did not consistently affect these two yield components. Smut was not a problem in 1976.

Dinoseb tended to decrease grain yield of both hybrids, though the yield differences were not significant (Table 3).

Table 2. CORN. Average number of days from emergence to 50% silking, average ear weight, and average number of ears per plant at Manhattan, Kansas.

Treatment	Rate	<u>Days to 50% silking</u>		<u>Ear weight</u>		<u>Ear number</u>	
		Dekalb	Pioneer	Dekalb	Pioneer	Dekalb	Pioneer
-----gm-----							
Control		57.8	61.8	164	191	0.92	0.94
Dinoseb	6.2	58.2	62.0	176	193	1.04	0.96
"	12.4	58.3	62.7	175	188	1.04	0.98
Surfactant		58.3	61.5	182	192	1.04	1.01
Benlate	1680.0	59.0	62.5	164	179	0.98	0.96
Nitrogen	1120.0	58.5	62.2	160	179	0.94	0.98

All other treatments tended to depress yield with the exception of surfactant applied on Dekalb XL64. Both Benlate and nitrogen solution treatments tended to decrease yields indicating that the mechanism of action may not be fungistatic as suggested by Hatley, et al. (4) and Regan (11), nor to the additional nitrogen.

Grain Sorghum Experiments.

At Manhattan, days from emergence to 50% flowering showed a significant treatment by growth stage of application interaction (Table 4, and Appendix Table 12). Application of 12.4 gm and 18.6 gm of dinoseb and 560 gm of ethephon significantly delayed flowering by 1.0, 1.2, and 1.2 days, respectively, when applied at growing point differentiation (GPD). Application during the flag or the boot stage did not affect flowering. When application was made at half-bloom, 12.4 gm dinoseb per hectare significantly hastened flowering by 1.2 days.

None of the treatments affected number of heads per plot or average weight per head. There was no time of application found to be best, and neither was any interaction found between treatments and time of application (Tables 5 and 6, and App. Table 12).

Ethephon at both rates (280 gm and 560 gm per hectare) significantly reduced number of kernels per head when compared to the control (Table 8). This effect was also noted visually in the reduction in head size and height of the plants in these two treatments which agrees with earlier work by Norwood (9), and Bolger and Gallagher (2). Norwood (9) reported visibly reduced head size in dryland grain sorghum and decreased yields,

Table 4. Grain Sorghum. Days from emergence to 50% flowering at Manhattan, Kansas.

Treatment	Rate	Growth Stages of application.			
		GPB	Flag	Boot	$\frac{1}{2}$ Bloom
	gm/ha				
Control		65.6	66.0	65.8	66.6
Dinoseb	6.2	65.8	65.4	65.8	66.4
"	12.4	66.6	66.2	65.4	65.4
"	18.6	66.4	65.6	66.4	65.8
"	24.8	65.6	66.2	66.0	66.2
Surfactant		65.8	66.4	65.8	65.6
Ethephon	280.0	65.8	66.0	66.4	65.8
"	560.0	66.8	65.8	65.4	66.2

LSD_{.05} = 1.0 for growth stage X treatment interaction.

Table 5. Grain Sorghum. Average number of heads per plot at Manhattan, Kansas.

Treatment	Rate	Growth Stages of application.			
		GPB	Flag	Boot	$\frac{1}{2}$ Bloom
	gm/ha				
Control		49.7	56.5	51.4	45.1
Dinoseb	6.2	46.8	56.4	52.6	53.0
"	12.4	50.0	52.4	53.0	58.5
"	18.6	53.6	55.2	51.4	54.2
"	24.8	48.0	56.4	45.4	60.8
Surfactant		52.4	50.2	51.7	55.8
Ethephon	280.0	57.2	52.6	52.6	53.3
"	560.0	49.2	52.6	51.0	52.1

particularly at higher rates of ethephon (1.12 and 2.24 kg per hectare). None of the dinoseb treatments differed from the control or surfactant in seed number. No interaction between treatment and time of application was found.

Neither treatments nor time of application affected kernel weight but there were highly significant interaction effects (Table 7, and Appendix Table 13).

Kernel weights from all dinoseb and surfactant treatments were not significantly different from the control but were significantly heavier than those from ethephon treated plots, when applied at GPD. This was reversed when application was made at the flag stage where 560 gm ethephon per hectare produced significantly heavier kernels than all the other treatments. Application of 280 gm ethephon per hectare at the boot stage gave heavier kernel weights than kernels from the control, surfactant, 12.4 gm and 18.6 gm dinoseb per hectare plots. No differences were found among the treatments when applied at the $\frac{1}{2}$ bloom stage.

Each of the treatments was evaluated for effect of the time of application. No differences were found in kernel weight due to the growth stage at which dinoseb treatments were applied. Application of the surfactant at GPD gave significantly heavier kernels than all other times of application. The lower rate of ethephon (280 gm/ha) gave highest kernel weights when applied at the boot stage while 560gm ethephon per hectare gave highest kernel weights at either the flag or boot stage.

Grain yield was not significantly increased by any of the treatments nor by any of the times of treatment application

Table 6. Grain Sorghum. Average weight per head at Manhattan, Kansas.

Treatment	Rate	Growth Stages of application.			
		GPD	Flag	Boot	$\frac{1}{2}$ Bloom
	gm/ha	-----gm-----			
Control		95.2	80.7	87.2	88.1
Dinoseb	6.2	100.2	79.6	87.8	96.3
"	12.4	88.9	85.6	84.5	81.3
"	18.6	83.4	83.6	86.7	85.2
"	24.8	95.5	85.5	96.3	79.7
Surfactant		98.0	84.0	85.6	82.8
Ethephon	280.0	80.3	81.4	85.6	82.7
"	560.0	86.7	79.0	85.1	83.0

Table 7. Grain Sorghum. Average weight of 1000 kernels at Manhattan, Kansas.

Treatment	Rate	Growth Stages of application.			
		GPD	Flag	Boot	$\frac{1}{2}$ Bloom
	gm/ha	-----gm-----			
Control		24.4	23.6	24.2	24.4
Dinoseb	6.2	25.0	23.6	25.0	24.4
"	12.4	25.1	23.9	24.4	24.5
"	18.6	24.9	23.8	24.0	24.0
"	24.8	24.9	23.5	24.8	23.7
Surfactant		25.3	23.6	24.2	23.8
Ethephon	280.0	23.3	24.7	25.8	23.5
"	560.0	23.0	26.8	25.2	24.2

LSD_{.05} = 1.3 (for between subplots, same time of application).
 = 1.6 (for same treatment, different times of application).

(Table 9, and Appendix Table 13). No interaction was also found. All dinoseb treatments gave slightly higher yields than the control while 560 gm of ethephon tended to reduce yields. These results agree with the concurrent work of Kapusta and Strieker (5) at Belleville, Illinois.

Tables 7 and 8 indicate why there were no yield differences due to either the treatments or the times these treatments were applied. The ethephon treatments gave significant decreases in kernel number but these were balanced by heavier kernels. Application of 6.2 gm dinoseb/ha gave above average kernel weight and had the highest kernel number per head which resulted in the highest yield of all the treatments, though the difference was not significant.

Yield data from Garden City, did not show any significant effects of dinoseb (Appendix Table 14). Yields were progressively reduced from 8831 kg/ha in the control to 8823 kg/ha, 8701 kg/ha, and 8263 kg/ha with the application of surfactant, 6.2 gm, and 12.4 gm dinoseb/ha, respectively.

Table 8. Grain Sorghum. Average number of kernels per head at Manhattan, Kansas.

Treatment	Rate	Growth Stages of application.			
		GPD	Flag	Boot	$\frac{1}{2}$ Bloom
	gm/ha				
Control		3908	3420	3592	3614
Dinoseb	6.2	4028	3370	3508	3928
"	12.4	3552	3564	3464	3330
"	18.6	3358	3516	3602	3556
"	24.8	3842	3600	3872	3366
Surfactant		3856	3560	3546	3492
Ethephon	280.0	3450	3284	3360	3530
"	560.0	3734	2956	3372	3424

LSD_{.05} = 227 for Treatments

Table 9. Grain Sorghum. Average grain yield at Manhattan, Kansas.

Treatment	Rate	Growth Stages of application.			
		GPD	Flag	Boot	$\frac{1}{2}$ Bloom
	gm/ha	-----kg/ha-----			
Control		7651	7409	7202	6540
Dinoseb	6.2	7661	7269	7517	8157
"	12.4	7233	7232	7195	7763
"	18.6	7306	7509	7194	7492
"	24.8	7463	7642	7051	7773
Surfactant		7954	6883	7237	7318
Ethephon	280.0	7463	6934	7367	7190
"	560.0	6614	6756	7082	6945

SUMMARY AND CONCLUSION.

Experiments were conducted at Manhattan in 1976 to study the effect of dinoseb on grain yield of corn, and the effects of dinoseb and ethephon on the yield of grain sorghum and to determine the best time of application of these chemicals on grain sorghum. Also in 1976, an experiment was conducted at Garden City to study the effect of dinoseb on the yield of irrigated grain sorghum.

There were no treatment differences nor any interaction between treatments and time of treatment application for any of the characters studied in the corn experiment.

In the sorghum experiment at Manhattan, two yield components, kernel weight and kernel number per head, were significantly affected. These two components compensated for each other so that no significant net yield differences due to the treatments applied or times of application were found. At Garden City with irrigated grain sorghum, there was a progressive decrease in yield with increase in the rate of dinoseb applied although these yield reductions were not significant.

In view of these results and previous studies by other workers (2, 5, 6, 9, 11, 14), it can be concluded that.:

- i) yield responses of corn and grain sorghum to foliar applications of dinoseb and ethephon have not been consistent.
- ii) no time was found to be best for application of both chemicals at the rates tried on grain sorghum.
- iii) the inconsistency of results so far indicates little or no benefits, at least in some mid-western states, from application of either chemical to these crops.

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APPENDIX.

Table 10. CORN. Analyses of variance for No. of days to 50% silking, Percent barren plants, Percent 2-eared plants, and Percent lodged plants at Manhattan, Kansas.

Source of variation	Degrees of freedom	Days to 50% silking	% barren plants	% 2-eared plants	% lodged plants
-----Mean Squares-----					
Replicates	5	6.38	10.64	9.46	35.4
Hybrids (H)	1	253.13**	0.89	133.93*	42.0
Error (a)	5	1.76	35.77	19.87	35.3
Treatments (T)	5	1.51	45.00	43.92	23.2
H X T	5	0.49	35.29	13.62	34.5
Error (b)	50	1.14	25.15	27.53	41.7

* Denotes significance at the 0.05 level of probability.

** Denotes significance at the 0.01 level of probability.

Table 11. CORN. Analyses of variance for 1000-kernel weight, No. of ears per plant, Ear weight, and grain yield at Manhattan, Kansas.

Source of variation	Degrees of freedom	1000 kernel weight	Ear no. per plant	Ear weight	Grain Yield
-----Mean Squares-----					
Replicates	5	213.25	0.00236	964	2131146
Hybrids (H)	1	10901.31**	0.00934	5224	6273296*
Error (a)	5	220.75	0.00892	1216	864834
Treatments	5	75.38	0.01454	573	462176
H X T	5	68.13	0.00668	96	234626
Error (b)	50	45.75	0.00755	453	544379

* Denotes significance at the 0.05 level of probability.

** Denotes significance at the 0.01 level of probability.

Table 12. Grain Sorghum. Analyses of variance for No. of days to flowering, Average no. of heads per plot, and average grain weight per head at Manhattan, Kansas.

Source of variation	Degrees of freedom	Days to flowering	No. heads per plot	Grain weight per head.
-----Mean Squares-----				
Replicates	4	22.34	387.8	294.99
Growth Stages (GS)	3	0.22	126.5	545.45
Error (a)	12	1.29	96.3	326.55
Treatments (T)	7	0.11	26.4	175.35
GS X T	21	1.06*	66.1	110.98
Error (b)	112	0.63	61.9	99.38

* Denotes significance at the 0.05 level of probability.

Table 13. Grain Sorghum. Analyses of variance for 1000 kernel weight, Average no. of kernels per head, and average grain yield per hectare at Manhattan, Kansas.

Source of variation	Degrees of freedom	1000 kernel weight	Kernel no. per head	Grain Yield
-----Mean Squares-----				
Replicates	4	14.78	272400	7337583
Growth Stages (GS)	3	3.62	640940	489802
Error (a)	12	4.82	233730	1252348
Treatments (T)	7	1.06	319630*	1093940
GS X T	21	3.69**	167770	543360
Error (b)	112	1.10	131140	734746

* Denotes significance at the 0.05 level of probability.

** Denotes significance at the 0.01 level of probability.

EFFECTS OF DINOSEB AND ETHEPHON ON THE YIELD
OF CORN (ZEa MAYS, L.) AND GRAIN SORGHUM
(SORGHUM BICOLOR, (L.) MOENCH).

by

SAMUEL TEMITAYO JAIYESIMI
B.Sc.(Agric.), Ahmadu Bello University, 1972.

AN ABSTRACT OF A MASTER'S THESIS

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Corn (Zea mays, L.) and grain sorghum (Sorghum bicolor, (L.) Moench) are two very important Great Plains crops that scientists are continuously seeking to increase the yield level. Dinoseb and ethephon have, in recent years, been applied on a variety of grain crops as yield stimulants. Responses of corn and grain sorghum have been varied.

These chemicals were used in experiments at Manhattan and Garden City in 1976 to evaluate their effects on the yield of corn and grain sorghum.

Three rates of dinoseb (0, 6.2, and 12.4 gm/ha), 1.56 kg/ha Benlate, 1.12 kg/ha nitrogen, and a surfactant (at 2.5% of the highest dinoseb rate) were applied separately on two corn hybrids (Dekalb XL64 and Pioneer 3369A). Six replications were used in a modified split-plot design with hybrids as main plots (strips) and treatments as sub-plots. Yield and yield components evaluated were not significantly affected by any of the treatments. There were also no hybrid by treatment interaction effects.

On grain sorghum (RS 671) at Manhattan, five rates of dinoseb (0, 6.2, 12.4, 18.6, and 24.8 gm/ha), surfactant (at 2.5% of highest dinoseb rate), and two rates of ethephon (280 and 560 gm/ha) were applied at four stages of development (growing point differentiation, flag leaf visible, boot stage, and $\frac{1}{2}$ bloom). The experimental design was also a split-plot with five replications. Main plots were time of treatment application (stages) and the treatments were sub-plots. Except for kernel weight and kernel number per head, no other yield component was significantly affected. Kernel weight and kernel number compensated for each other with the net effect being no

significant yield differences due to the treatments. Ethephon (560 gm/ha) was found to visibly reduce head size which was reflected in kernel number per head being the least of all the treatments, and being significantly lower than the control.

Three rates of dinoseb (0, 6.2, and 12.4 gm/ha) were tried on irrigated grain sorghum at Garden City in 1976. Yields tended to decrease with increasing dinoseb rate although the yield reductions were not significant.

Benefits from foliar applications of dinoseb and ethephon are doubtful since these results and those of other researchers have not been consistently positive.